OPTICAL SCANNER

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EC Classification:
Equivalents:

Abstract

PURPOSE:To reduce or prevent the ununiformity of the spot diameter on the scanning surface by providing a second lens group consisting of an image forming lens provided with an ftheta characteristic and an image bending correcting lens having a special toric surface on a deflecting device side between the deflecting device and the scanning surface. CONSTITUTION:A second lens group for bring a luminous flux deflected by a rotary polygon mirror 4 to image formation in a shape of a spot on the scanning surface 7 is provided with an image forming lens 52 provided with an ftheta characteristic, and an image bending correcting lens 51 placed between the lens 52 and a deflecting device 4. The image bending correcting lens 51 is a troidal lens whose incident surface has a special toric surface of a shape obtained by rotating a shape given by an edge line 51A around a rotary axis RX. This special toric surface has a negative radius of curvature in the main scanning direction and has a positive radius of curvature in the sub-scanning direction. Also, power in the sub-scanning direction decreases as it is separated from an optical axis in the main scanning direction, therefore, an image bending in the sub-scanning direction as the whole second lens group can be corrected.

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(54)TITLE OF THE INVENTION: Light scanning apparatus

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SPECIFICATION

TITLE OF THE INVENTION

Light scanning apparatus

CLAIMS:

1. A light scanning apparatus comprising a light source, a first lens group for imaging a beam from the light source as a line image extending in a direction corresponding to main-scanning, a deflecting device, having a plurality of deflecting surfaces, for deflecting the beam about a position adjacent the line image formed by said first lens group, and a second lens group, disposed between the deflecting device and a surface to be scanned, for imaging the deflected beam as a spot on the surface to be scanned,

wherein said second lens group includes an imaging lens having a $f\theta$ property, and a field curvature correcting lens disposed between said imaging lens and said deflecting device, and said second lens group is effective to focus the deflected beam on the surface to be scanned with respect to a main scan direction, and is effective to make the surface to be scanned and the imaging position of the line image by the first lens group substantially conjugate with each other, and at least one surface is

P3 a field curvature correcting surface, and

2 wherein said field curvature correcting lens

3 is a special toroidal lens having a special toric

4 surface at a deflecting device side;

5 wherein said special toric surface has a

6 geometrically negative radius of curvature with

7 respect to the main scan direction, and has a surface

8 configuration provided by rotating, about an axis

9 parallel with the main scan direction adjacent a

10 surface to be scanned beyond the special toric

11 surface, a configuration defined by a general equation

12 of aspherical surface.

13

14 2. A light scanning apparatus according to Claim

15 1, wherein a radius of curvature R, on the optical

16 axis, of a configuration of the special toric surface

17 as seen in the sub-scan direction and the focal length

18 of said second lens group satisfy:

19 $0.3 < |R/f| < 1.0$.

20

21 DETAILD DESCRIPTION OF THE INVENTION

22 (APPLICABLE FIELD OF INDUSTRY)

23 The present invention relates to a light

24 scanning apparatus.

25 (PRIOR ART)

26 A light scanning apparatus is well-known

27 which comprises a light source, a first lens group for

imaging a beam from the light source as a line image extending in a direction corresponding to main-scanning, a deflecting device, having a plurality of deflecting surfaces, for deflecting the beam about a position adjacent the line image formed by said first lens group, and a second lens group, disposed between the deflecting device and a surface to be scanned, for imaging the deflected beam as a spot on the surface to be scanned.

In such an optical scanning apparatus, in order to prevent the variation, in the sub-scan direction, of the main-scanning position, attributable to the mechanical error in the deflecting device, that is, so-called surface tilting, the second lens group comprises an imaging lens having a $f\theta$ function and a cylindrical lens disposed between the imaging lens and the deflecting device, so that, in the main scan direction, the deflected beam is imaged on the surface to be scanned, and in the sub-scan direction, the imaging position of a line image formed by the first lens group and the surface to be scanned are made substantially conjugate with each other (Japanese Patent Application Publication Sho 52- 28666, for example).

(PROBLEM TO BE SOLVED)

Such a light scanning apparatus involves the following problems.

P5 In Figure 6, designated by reference numeral 2 1 is a semiconductor laser, and reference numeral 2 is 3 a collimator lens. These elements constitute a light 4 source and provide a substantially parallel beam. The 5 substantially parallel beam from the light source is 6 imaged as a line image LI which is elongated in a 7 direction corresponding to the main-scanning, by the 8 cylindrical lens 3 constituting the first lens group.

9 A rotatable polygonal mirror depicted by a 10 reference numeral 4 functions as a deflecting device 11 and has a plurality of deflecting surfaces, and it 12 deflects the beam with the center of deflection 13 adjacent the line image LI.

14 In Figure 6, designated by reference numeral 15 5 is an is an imaging lens, and reference numeral 6 is 16 a cylindrical lens. The imaging lens 5 and the 17 cylindrical lens 6 constitute a second lens group. 18 The deflected beam from the rotatable polygonal mirror 19 4 is imaged in the form of a spot on the surface to be 20 scanned 7 by the second lens group and scans the 21 surface to be scanned 7. The direction in which the 22 spot moves is the main scan direction. The direction 23 perpendicular to the main scan direction in the 24 surface to be scanned 7 is the sub-scan direction.

25 The second lens group functions to provide a 26 conjugate relation between the imaging position of the 27 line image LI and the surface to be scanned in the

P6 sub-scan direction. Therefore, in the sub-scan
2 direction, an image of the line image is formed on the
3 surface to be scanned 7 by the second lens group.
4 On the other hand, the deflected beam
5 incident on the second lens group remains a parallel
6 beam with respect to main scan direction, and the
7 second lens group provides a conjugate relation
8 between the infinity position in the object side and
9 the position of the surface to be scanned 7 with
10 respect to the main scan direction.
11 In order to acquire such an anamorphic
12 property, the second lens group has to have a stronger
13 power in the sub-scan direction as compared with that
14 in the main scan direction. For this reason, the
15 cylindrical lens 6 does not have power in the main
16 scan direction but has a positive power in the
17 sub-scan direction.
18 The imaging lens 5 is a so-called $f\theta$ lens
19 having a $f\theta$ function.
20 Figure 7 is a view of a portion between the
21 center of deflection of the rotatable polygonal mirror
22 4 and the surface to be scanned 7, as seen in the
23 sub-scan direction.
24 When the above-described second lens group is
25 used, the correction of the astigmatism in the
26 sub-scan direction is difficult because the power in
27 the sub-scan direction is stronger than that in the

P7 main scan direction, with the result that as shown in
2 Figure 7, a locus 8 of the beam imaging point P in the
3 sub-scan direction is curved in the form of arcuation
4 toward the second lens group. Then, the deflected
5 beam is divergent in the sub-scan direction away from
6 the point P toward the surface to be scanned 7, and
7 therefore, the diameter of the spot SP on the surface
8 to be scanned 7 becomes larger in the sub-scan
9 direction away from the optical axis of the second
10 lens group in the main scan direction, so that spot
11 diameter is not uniform in the main scan direction.
12 For this reason, optical scanning is not possible with
13 a high resolution exceeding 400dpi.
14 Accordingly, the present invention is made in
15 consideration of the circumstances, and it is an
16 object of the present invention to provide a novel
17 optical scanning apparatus wherein the non-uniformity
18 of the spot diameter can be effectively reduced or
19 prevented.
20 (MEANS FOR SOLVING THE PROBLEM)
21 The description will be made as to the
22 present invention.
23 The optical scanning apparatus comprises a
24 light source, the first and second lens groups and a
25 deflecting device.
26 The first lens group functions to focus the
27 beam emitted from the light source to form a line

P8 image extending in a direction corresponding to the
2 main-scanning.
3 The deflecting device has a plurality of
4 deflecting surfaces, and functions to deflect the beam
5 about a position adjacent the imaging position of the
6 line image formed by the first lens group.
7 The second lens group is disposed between the
8 deflecting device and the surface to be scanned, and
9 functions to focus the deflected beam into a spot on
10 the surface to be scanned.
11 The second lens group, as shown in Figure 1,
12 comprises an imaging lens 52 having a $f\theta$ property and
13 a field curvature correcting lens 51 disposed between
14 the imaging lens 52 and the deflecting device 4 to
15 function to image the deflected beam on the surface to
16 be scanned in the main scan direction and to function
17 to provide a substantially conjugate relation between
18 the imaging position of the line image by the first
19 lens group and the surface to be scanned.
20 The field curvature correcting lens is a
21 special toroidal lens having a special toric surface
22 at the deflecting device side.
23 The special toric surface has a configuration
24 which has a geometrically negative radius of curvature
25 with respect to the main scan direction, and a surface
26 configuration provided by rotating, about an axis
27 parallel with the main scan direction adjacent the

P9 surface to be scanned beyond the special toric
2 surface, a configuration defined by a general equation
3 of aspherical surface.
4 The optical scanning apparatus as defined in
5 Claim 2 includes the following further feature in
6 addition to the features of Claim 1. Namely, the
7 radius of curvature R on the optical axis in the
8 configuration of said special toric surface as seen in
9 the sub-scan direction, and the focal length f of said
10 second lens group satisfy:
11 $0.3 < |R/f| < 1.0$.
12 The imaging lens having the $f\theta$ function may
13 be a single lens or a compound lens comprising two or
14 more lens elements, and any surface of the lens may be
15 aspherical surface.
16 (FUNCTION)
17 The inventions as defined in Claims 1 and 2
18 commonly includes the following features:
19 First, the second lens group is constituted
20 by an imaging lens and a field curvature correcting
21 lens, and secondly, a special toric surface for field
22 curvature correction in the field curvature correcting
23 lens is disposed closest to the deflecting device in
24 the second lens group.
25 The invention of Claim 2, includes, in
26 addition to the above-described feature, the feature
27 that special toric surface satisfies $0.3 < |R/f| <$

P10 1.0.

Referring to Figure 2, the configuration of the field curvature correcting lens 51 will be described.

In Figure 2, the lenses are shown in a perspective view with a part of the configuration omitted. The left side in the Figure is an incident side, that is, the deflecting device side.

The field curvature correcting lens 51 is a special toroidal lens which is concave at the incident side as seen in the sub-scan direction. And, the incident side surface thereof constitutes a special toric surface.

The special toric surface has the following features. As seen in the sub-scan directing direction, the configuration of the special toric surface is given by a ridge line 51A of the special toric surface, and the configuration of the ridge line is expressed by a general formula of an aspherical surface. Therefore, the configuration includes a circle shape as a special case.

The special toric surface has a configuration provided by rotating the line defined by the ridge line 51A about a rotational axis RX.

The rotational axis RX is perpendicular to the optical axis and is parallel with the main scan direction, and it is disposed adjacent the surface to

P11 be scanned beyond the special toric surface, that is,
2 the righthand side area in Figure 2. As a result,
3 when the field curvature correcting lens 51 is cut
4 along a plane parallel both to the optical axis and
5 the sub-scan direction, the configuration of the cut
6 end of the special toric surface is circular. The
7 radii of the circles take a minimum value on the
8 optical axis, and increases away from the optical axis
9 in the main scan direction.
10 Thus, the special toric surface geometrically
11 has a negative radius of curvature in the main scan
12 direction and has a positive radius of curvature in
13 the sub-scan direction. And, the power in the
14 sub-scan direction decreases away from the optical
15 axis in the main scan direction. Therefore, the field
16 curvature of the entirety of the second lens group in
17 the sub-scan direction can be corrected.
18 The field curvature correcting lens 51 has
19 hardly any power in the main scan direction.
20 The description will be made as to the
21 significance of disposing the special toric surface
22 for the field curvature correction at a position
23 closest to the deflecting device in the second lens
24 group.
25 Figure 9 shows the optical system of the
26 optical scanning apparatus shown in Figure 6, which is
27 expanded along the optical system.

P12 In order to effect a good optical scanning operation, it is necessary that spot configuration of the scanning light is stabilized in the main- and sub-scan directions as described hereinbefore. The spot configuration may desirably circular or close to a circular shape. In consideration of the fact that spot is formed by a beam waist, in order to realize the substantially circular spot configuration, it is necessary that converging tendencies of the beam condensing on the surface to be scanned 7, in the main-scanning and sub-scan directions, are substantially equal to each other, in other words, that exit pupils NA of the second lens group for the converging beam in the main- and sub-scan directions are substantially equal to each other.

In Figure 9, since the cylindrical lenses 3, 6 have no power in the main scan direction, the imaging relationship between the semiconductor laser 1 and the surface to be scanned 7 is as shown by the solid line. On the other hand, in the sub-scan direction, since the cylindrical lenses 3, 6 have powers, the imaging beam between the semiconductor laser 1 and the surface to be scanned 7 is as indicated by hatching when the NAs in the main- and sub-scan directions are equal as described above. It will be understood that in order to satisfy the condition that NAs in the main- and sub-scan direction

P13 are equal, the beam has to be restricted in the
2 sub-scan direction as indicated by the hatching in
3 Figure 9. However, doing so will reduce the usage of
4 light.

5 In order to increase the usage of light is
6 increased by avoiding this problem, the focal length
7 of the cylindrical lens 3 may be increased to an
8 extent equivalent to the focal length of the second
9 lens group. However, if this is done, the optical
10 scanning apparatus is upsized.

11 Figure 5 shows the optical scanning apparatus
12 expanded along the optical path. In this Figure, the
13 second lens group is indicated as a single lens 50.

14 In the present invention, the anamorphic
15 property of the second lens group is realized by the
16 special toric lens, and the special toric lens is
17 disposed at the incident side of the imaging lens
18 closely to the imaging lens. In addition, the special
19 toroidal surface is the closest to the deflecting
20 device 4, and therefore, the object side focal length
21 of the second lens group in the sub-scan direction can
22 easily be made substantially the same as the focal
23 length of the cylindrical lens 3. The exit pupil
24 diameters NA of the second lens group in the main and
25 sub-scan directions, can be made substantially equal
26 to each other as shown in Figure, and the usages of
27 the light in the main and sub-scan directions are made

P14 substantially equal, and therefore, the usage of the
2 light can be significantly improved without upsizing
3 the optical scanning apparatus.
4 The description will be made as to the
5 condition, in Claim 2, that is:
6 $0.3 < |R/f| < 1.0$.
7 Here, R is a radius of curvature, on the
8 optical axis, of a configuration of the special toric
9 surface as seen in the sub-scan direction, and f is a
10 focal length of the second lens group.
11 The condition determines a practical range of
12 the field curvature correction in the sub-scan
13 direction. If the lower limit is exceeded, the
14 correction of the field curvature is excessive with
15 the result that field curvature increases in the
16 positive direction. If the upper limit is exceeded,
17 the correction of the field curvature is not
18 sufficient. Accordingly, the range is practical.
19 The lens surface, at the surface adjacent the
20 surface to be scanned, of the field curvature
21 correcting lens 51, that is, the surface r2 is formed
22 by a spherical surface or aspherical surface which is
23 symmetric with respect to the optical axis. With such
24 a formation, the machinability is improved, and the
25 cost is reduced, and in addition, the optical
26 characteristics are stabilized, as compared with the
27 frequently used special configuration case wherein the

powers in the main scan direction and the sub-scan direction are different from each other.

On the contrary, when the imaging lens is constituted by a single lens, the radius of curvature r4 on the optical axis of the emergent side lens surface, and the focal length of the second lens group, desirably satisfy

$$0.4 < |r4/f| < 1.5.$$

This condition is concerned with the $f\theta$ property, and if the upper limit is exceeded, the negative distortion remarkably increases, with the result that $f\theta$ property is not sufficient, and the curvature of the image surface in the negative direction increases. If the lower limit is exceeded, the negative distortion decreases too much, and a sufficient $f\theta$ property is not provided. Therefore, it is desirable to satisfy the condition from the practical standpoint.

(EMBODIMENT)

Two detailed examples will be described.

In implementing the embodiments, the light source and the first lens group may be a combination of a known light source device emitting aforcal beam and a cylindrical lens having positive power, for example, a combination disclosed in Japanese Patent Application Publication Sho 52-2866.

In the following embodiments, only the data

of the second lens group which constitutes the characterizing portion.

In each of the embodiments, as shown in Figure 1, the second lens group is constituted by the field curvature correcting lens 51 and the imaging lens 52 which is a single lens.

As shown in Figure 1, the radii of curvatures of the respective surfaces are r0, r1x, r1y, r2x, r2y, r3, r4 from the deflecting device 4 side, and the spaces are d0, d1- d4. Suffix "X" in the radii of curvatures indicates those in the main scan direction, and "Y" indicates those in the sub-scan direction.

In each of the embodiments, j= 1 indicates field curvature correcting lens, j= 2 indicates imaging lens, and nj are refractive indices of the materials of the lenses.

Example 1

i	rx, y	d1	j	nj	material
0	∞	46.0			
1x	-92.500	6.0	1	1.486	acrylic resin
1y	29.480				
2x	-92.500	5.0			
2y	-92.500				
3*	399.434	25.0	2	1.486	acrylic resin
4	-111.618	175.122			

P17 R/f=r1x/f=-0.514, r4/f=-0.62114, The focal length of the second lens group: f= 179.7 In this embodiment, the configuration of the special toric surface in the main scan direction, that is, the configuration of the special toric surface as seen in the sub-scan direction, is arcuate with a radius of curvature r1x =-92.500, and the radius of curvature of the special toric surface on optical axis in the sub-scan direction is r1y= 29.480.

The lens surface of the imaging lens at the incident side (with asterisk) is aspherical surface, and it is expressed by a known general formula of aspherical surface, as follows:

$$X = \{(1/r)^2Y^2\}/[1+\sqrt{1-(1+k)(1/r)^2}] +AY4+BY^6+CY^8+DY^{10}$$

where the conical constant k, the high order non-spherical coefficients A, B, C, D are: k=-3.26973·10^{-1}

A=-1.57 53·10^{-7}, B=5.90134·10^{-11}

C=-1.97907·10^{-14}, D=2.52778·10^{-1}

Figure 3 shows aberration diagrams of Embodiment 1.

Example 2

P18	i	rx, y	d1	j	nj	material
2	0	∞	46.0			
3	1x*	-92.500	6.0	1	1.486	acrylic resin
4	1y	29.480				
5	2x	-92.500	5.0			
6	2y	-92.500				
7	3*	399.434	25.0	2	1.486	acrylic resin
8	4	-111.618	175.122			
9						

R/f=r1x/f=-0.514, r4/f=-0.62114,

The focal length of the second lens group: f= 179.7 In this embodiment, the configuration of the special toric surface in the main scan direction, that is, the configuration of the special toric surface as seen in the sub-scan direction, is expressed by the general formula of aspherical surface, and the radius of curvature of the special toric surface on optical axis in the sub-scan direction is r1y= 29.480.

The lens surface of the imaging lens at the incident side (with asterisk) is also an aspherical surface.

K, A, B, C, D defining the non-spherical configuration are as follows:

The configuration of the special toric surface in the main scan direction:

$k=-6.32029\cdot10^{-1}$

$A=6.70608\cdot10^{-9}$, $B=5.99831\cdot10^{-12}$

The lens surface of the imaging lens at the incident side

$k=-1.39881$

$A=-2.03709\cdot10^{-7}$, $B=5.14928\cdot10^{-11}$

$C=-1.26063\cdot10^{-14}$, $D=1.41459\cdot10^{-18}$

Figure 4 shows aberration diagrams of Embodiment 1.

(ADVANTAGEOUS EFFECT OF THE INVENTION)

As described in the foregoing, a novel optical scanning apparatus can be provided. In the optical scanning apparatus, the second lens group has a field curvature correcting surface, and the field curvature correcting surface corrects the field curvature in the sub-scan direction, and therefore, the variation of the spot configuration on the surface to be scanned can be effectively reduced or prevented. Accordingly, it is usable for optical scanning with high resolving power such as 400- 800dpi.

In addition, the field curvature correcting surface is disposed at a position closest to the deflecting device, the second lens group can be downsized, so that light usage can be remarkably improved without upsizing the apparatus.

These and other objects, features and advantages of the present invention will become more

P20 apparent upon a consideration of the following
2 description of the preferred embodiments of the
3 present invention taken in conjunction with the
4 accompanying drawings.
5
6 BRIEF DESCRIPTION OF THE DRAWINGS:
7 Figure 1 illustrates a structure of a lens
8 which includes the feature of the present invention;
9 Figure 2 illustrates the characterizing feature;
10 Figures 3 and 4 are aberration diagrams of
11 embodiments; Figure 5 illustrates advantageous effects
12 of the present invention; Figure 6 through Figure 9
13 illustrate prior-art and problems involved therein.
14 LI =line image:
15 3= cylindrical lens:
16 52= imaging lens
17 51= field curvature correcting lens.
18 Applicant: (223) Kabushiki Kaisha Sankyoseiki
19 Seisakusho
20

第 1 図

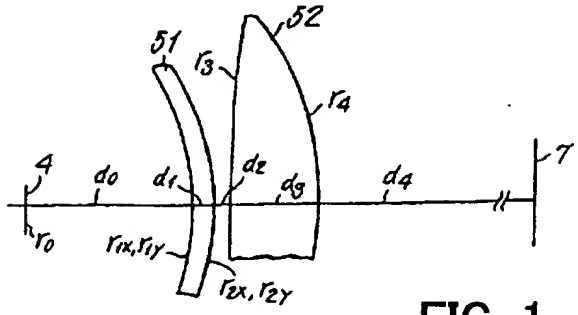

FIG. 1

第 2 図

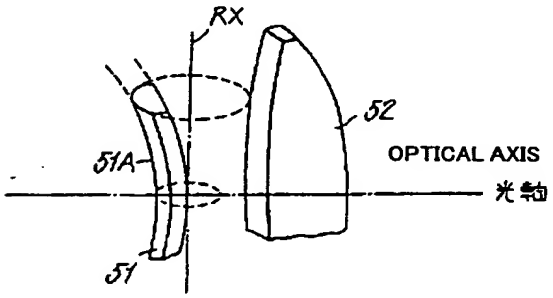

FIG. 2

第 3 図

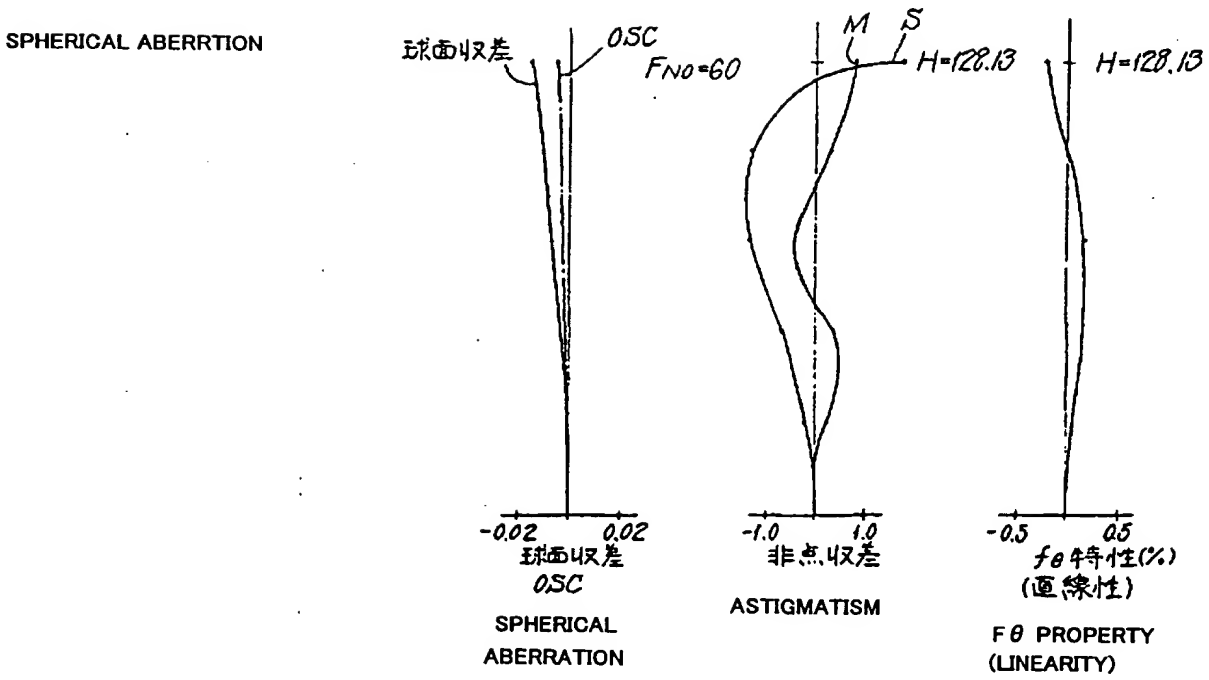

FIG. 3

第 4 図

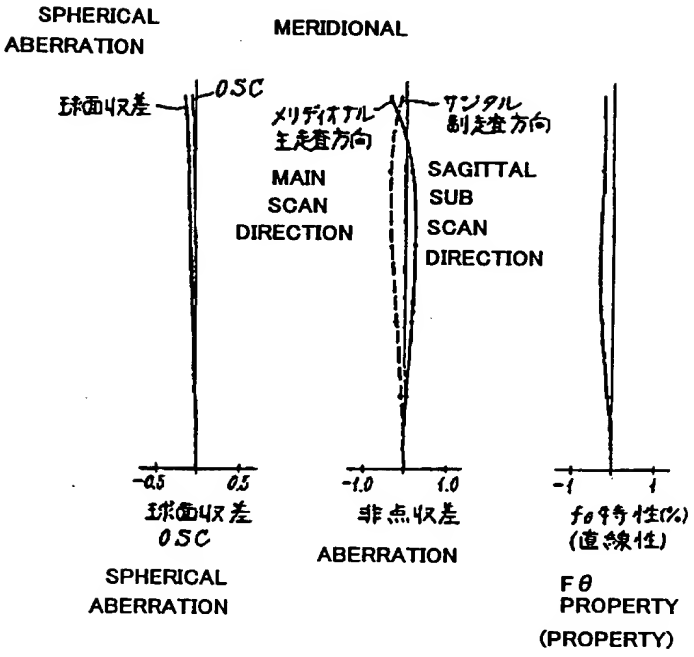

FIG. 4

第 5 図

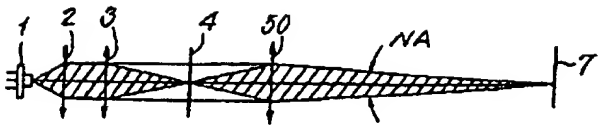

FIG. 5

第 6 図

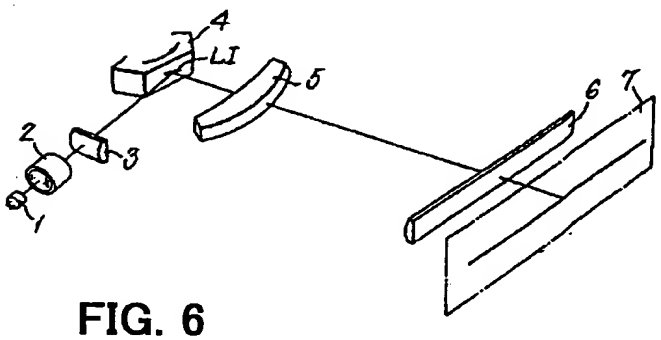

FIG. 6

第 7 図

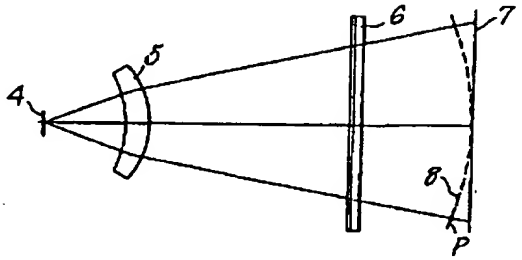

FIG. 7

第 8 図

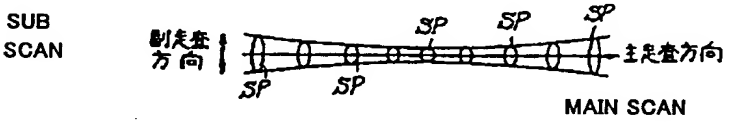

FIG. 8

第 9 図

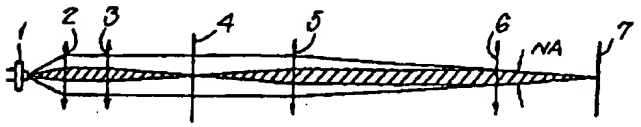

FIG. 9

⑲日本国特許庁（JP）　⑪特許出願公開

⑫公開特許公報（A）　平2－109012

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3/06		7036－2H	

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㉒出　願　昭63(1988)10月19日

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明　細　書

発明の名称

光走査装置

特許請求の範囲

光源と、この光源からの光束を主走査対応方向に長い線像に結像させる第1レンズ群と、複数の偏向面を有し上記第1レンズ群による上記線像の近傍を偏向の起点として光束を偏向させる偏向装置と、この偏向装置と走査面との間に配備され偏向光束を走査面上にスポット状に結像させる第2レンズ群とを有し、

上記第2レンズ群は、f θ特性を備えた結像レンズと、この結像レンズと上記偏向装置との間に配備される像面湾曲補正レンズとを有し、主走査方向に関して、偏向光束を走査面上に結像させるとともに副走査方向に関しては上記第1レンズ群による線像の結像位置と走査面とを略共役な関係とする機能を有し、

上記像面湾曲補正レンズは、上記偏向装置側に特殊トーリック面を持つ特殊なトロイダルレンズであり、

上記特殊トーリック面は、幾何光学的には主走査方向に関しては負の曲率半径を持ち、副走査方向から見た形状が非球面の一般式に従う形状であり、この形状を特殊トーリック面より走査面側にあって主走査方向に平行な回転軸の回りに回転させて得られる形状であることを特徴とする光走査装置。

2．請求項1に於いて、

特殊トーリック面を副走査方向から見た形状に於ける光軸上の曲率半径をR、第2レンズ群の焦点距離をfとするとき、これらが

$$0.3 < |R/f| < 1.0$$

なる条件を満足することを特徴とする、光走査装置。

発明の詳細な説明

（産業上の利用分野）

本発明は、光走査装置に関する。

（従来の技術）

光源と、この光源からの光束を主走査対応方向

に長い線像に結像させる第１レンズ群と、複数の偏向面を有し第１レンズ群による上記線像の近傍を偏向の起点として光束を偏向させる偏向装置と、この偏向装置と走査面との間に配備され偏向光束を走査面上にスポット状に結像させる第２レンズ群とを有する光走査装置は良く知られている。

このような光走査装置では偏向装置の機械的な誤差に起因する、主走査位置の副走査方向への変動、即ち所謂面倒れを防止するために、第２レンズ群を、ｆθ機能を持つ結像レンズと、この結像レンズと偏向装置の間に配されるシリンドリカルレンズとにより構成し、主走査方向に関しては偏向光束を走査面上に結像させ、副走査方向に関しては第１レンズ群による線像の結像位置と走査面とを略共役の関係にすることが行われている（例えば、特公昭52-28666号公報）。

（発明が解決しようとする課題）

このような光走査装置には、以下の如き問題があった。

第６図で、符号１は半導体レーザー、符号２はコリメートレンズを示す。これらは光源を構成し略平行な光束を与える。光源からの略平行な光束は、次いで第１レンズ群をなすシリンドリカルレンズ３により主走査対応方向を長手方向とする潜像LIに結像される。

符号４をもって示す偏向装置としての回転多面鏡は複数の偏向面を有し、線像LIの近傍を偏向の起点として光束を偏向させる。

第６図において、符号５は結像レンズ、符号６はシリンドリカルレンズを示す。これら結像レンズ５、シリンドリカルレンズ６は、第２レンズ群を構成する。回転多面鏡４により偏向される偏向光束は、上記第２レンズ群により走査面７上にスポット状に結像し、走査面７を走査する。このときスポットの移動する方向が主走査方向である。また、走査面７上に於いて主走査方向と直交する方向が副走査方向である。

第２レンズ群は、副走査方向に関しては上記線像LIの結像位置と走査面とを略共役の関係としている。従って副走査方向に関しては上記線像の像

が、第２レンズ群により走査面７上に結像する。

一方、第２レンズ群に入射する偏向光束は主走査方向に関しては平行光束のままであり、第２レンズ群は主走査方向に関しては、物体側の無限遠と走査面７の位置とを共役関係とする。

このようなアナモフィックな性格を持つために第２レンズ群は、主走査方向に比して副走査方向のパワーが大きくなければならない。このためシリンドリカルレンズ６は主走査方向にパワーを持たず、副走査方向に正のパワーをもっている。

なお、結像レンズ５は所謂ｆθレンズであってｆθ機能を有する。

第７図は、第６図に於ける回転多面鏡４による偏向の起点から走査面７までの間の部分を副走査方向から見た状態を示している。

上記の如き第２レンズ群を用いると、副走査方向のパワーが主走査方向のパワーより大きいため副走査方向での非点収差の補正が困難となり、第７図に示すように、副走査方向での光束結像点Ｐの軌跡８は円弧状に第２レンズ群側へ湾曲してしまう。すると、上記Ｐ点より走査面７側へ向かうにつれて偏向光束は副走査方向に於いて発散性となるから、第８図に多少誇張して示すように、走査面７上のスポットSPは、主走査方向へ第２レンズ群の光軸を離れるに従って副走査方向のスポット径が次第に大きくなってしまい、スポット径が主走査方向に於いて均一にならない。このため400dpi以上のような高分解能の光走査を行うことができない。

本発明は上述した事情に鑑みてなされたものであって、その目的とする所は、上記スポット径の不均一を有効に軽減ないし防止しうる新規な光走査装置の提供にある。

（課題を解決するための手段）

以下、本発明を説明する。

請求項１の光走査装置は、光源と、第１，第２レンズ群と、偏向装置とを有する。

第１レンズ群は、光源からの光束を主走査対応方向に長い線像に結像させるためのレンズ群である。

置は、複数の偏向面を有し第１レンズ群
像の結像位置の近傍を偏向の起点として
向させる装置である。
ンズ群は、この偏向装置と走査面との間
れ偏向光束を走査面上にスポット状に結
レンズ群である。
２レンズ群は第１図に示すように、ｆθ
えた結像レンズ52と、この結像レンズ52
置４との間に配備される像面湾曲補正レ
を有し、主走査方向に関して偏向光束を
に結像させるとともに副走査方向に関し
第１レンズ群による線像の結像位置と走
略共役な関係とする機能を有する。
面湾曲補正レンズは、上記偏向装置側に
リック面を持つ特殊なトロイダルレンズ

殊トーリック面は、幾何光学的には主走
関しては負の曲率半径を持ち、副走査方
た形状が非球面の一般式に従う形状であ
形状を特殊トーリック面より走査面側に

あって主走査方向に平行な回転軸の回りに回転さ
せて得られる形状である。

請求項２の光走査装置は、上記請求項１の光走
査装置の特徴に加えてさらに次の特徴を有する。
即ち、特殊トーリック面を副走査方向から見た形
状に於ける光軸上の曲率半径をR、第２レンズ群
の焦点距離をｆとするとき、これらが

$$0.3 < |R/f| < 1.0$$

なる条件を満たすことである。

ｆθ機能を持つ結像レンズは、単レンズであっ
ても良く、あるいは２枚以上の複合レンズであっ
ても良く、更にこれらのうちのいずれかの面を非
球面で形成しても良い。

（作　　用）

本発明は，請求項１，２の発明を通じて以下の
如き特徴を主として有する。

第１は、第２レンズ群が結像レンズと像面湾曲
補正レンズにより構成されること、第２は、上記
像面湾曲補正レンズに於いて実際に像面湾曲補正
を行うための特殊トーリック面が第２レンズ群中

一１と走査面７と
の如く主・副走査
を施した光束部分
NAを等しくすると
副走査方向の光束
込む必要があり、
てしまう。
効率をあげるには
距離を第２レンズ
すれば良いが、こ
型化を招来してし

置を光路に沿って
符号50は第２レン
示している。
アナモフィックな
により実現され、
ンズが結像レンズ
て置かれ、さらに
に最も近接してい

向装置よりに配されていることである。
請求項２の発明では上述の特徴に加えて
リック面が上述の条件0.3<|R/f|<1.0
る。

先ず上記像面湾曲補正レンズ51の形状
第２図を参照して説明する。
で各レンズはその形状の一部を切り欠か
で斜視図的に示されている。図の左側が
ら偏向装置側である。
補正レンズ51は、副走査方向から見る
に凹形状をなす特殊なトロイダルレン
そしてその入射側の面が特殊なトーリ
成する。
なトーリック面は以下の如き特徴を持
即ち、この特殊トーリック面を副走査
ると、その形状は特殊トーリック面の
より与えられるが、この陵線の形状は
般式により表される。従って、この形
場合として円形状を含んでいる。
リック面は、上記陵線51Aで与えられ

る形状を回転軸RXの回りに回転して得られる形状
を有する。

回転軸RXは光軸に直交し、主走査方向に平行で
あって、且つ特殊トーリック面よりも走査面側、
即ち第２図で右側にある。この結果、像面湾曲補
正レンズ51を光軸、副走査方向の双方に平行な平
面で切断すると特殊トーリック面の切り口の形状
は円形状となり、この円の半径は光軸上で最も小
さく、光軸から主走査方向へ離れるに従って大き
くなる。

かくして、特殊トーリック面は幾何光学的には、
主走査方向には負の曲率半径を持ち、副走査方向
には正の曲率半径を持つ。そして副走査方向のパ
ワーは光軸を主走査方向に離れるに従い減少する。
従って、第２レンズ群全体としての副走査方向の
像面湾曲の補正が可能となる。

なお、像面湾曲補正レンズ51は主走査方向には
殆どパワーを持たない。

次に、像面湾曲補正を行うためのかかる特殊ト
ーリック面を、第２レンズ群中の最も偏向装置よ

の走査面側のレン
または非球面によ
成されることによ
主走査方向と副走
特殊形状のものに
になると同時に光
ることができる。
で構成する場合、
の曲率半径をr₄、
するとき、これら

い。
るものであって、
く増大しｆθ特性
なり、また像面の
た、下限を越える
はり十分なｆθ特
の条件の充足が実

用上からして望ましい。

［実施例］

以下、具体的な実施例を2例挙げる。

各実施例を実現する上で、光源及び第1レンズ群としては、平行光束を放射する公知の光源装置と正のパワーを持つシリンドリカルレンズとを組合せたもの、例えば前述の特公昭52-28666号公報記載のもの等を用いることができる。

以下に挙げる実施例では、特徴部分を構成する第2レンズ群のみのデータを挙げる。

各実施例とも、第1図に示すように像面湾曲補正レンズ51と単レンズの結像レンズ52とにより第2レンズ群が構成されている。

第1図に示すように、各面の曲率半径を偏向装置4の側から$r_0, r_{1x}, r_{1y}, r_{2x}, r_{2y}, r_3, r_4$、面間隔を$d_0, d_1$～$d_4$とする。曲率半径に於ける添字のXは主走査方向に関するものであることを、Yは副走査方向に関するものであることを示す。

また各実施例に於いてj=1は像面湾曲補正レンズ、j=2は結像レンズを表し、n_jはこれらレンズの材質の屈折率を示す。

実施例1

i	r_{ix}, r_{iy}	d_i	j	n_j	材質
0	∞	48.0			
1x	-92.500	6.0	1	1.486	アクリル
1y	29.480				
2x	-92.500	5.0			
2y	-92.500				
3*	399.434	25.0	2	1.486	アクリル
4	-111.618	175.122			

$R/f=r_{1x}/f=-0.514, r_4/f=-0.62114$, 第2レンズ群の焦点距離：f=179.7

この実施例に於いて、特殊トーリック面の主走査方向の形状即ち、特殊トーリック面を副走査方向から見た状態での形状は曲率半径$r_{1x}=-92.500$の円弧形状であり、この特殊トーリック面の光軸上に於ける副走査方向の曲率半径が上記$r_{1y}=29.480$である。

また結像レンズの入射側レンズ面（＊印を付けた面）は非球面であり、

公知の非球面の一般式を

$$X=\{(1/r)^2Y^2\}/[1+\sqrt{1-(1+k)(1/r)^2}]+AY^4+BY^6+CY^8+DY^{10}$$

とするとき、円錐定数k、高次の非球面係数 A,B,C,Dは以下の値を取る。

$k=-3.26973\cdot10^{-1}$

$A=-1.57653\cdot10^{-7}$,$B=5.90134\cdot10^{-11}$

$C=-1.97907\cdot10^{-14}$,$D=2.52778\cdot10^{-18}$

実施例1に関する収差図を第3図に示す。

実施例2

j	r_{ix}, r_{iy}	d_i	j	n_j	材質
0	∞	48.0			
1x	-92.500	6.0	1	1.486	アクリル
1y	29.480				
2x	-92.500	5.0			
2y	-92.500				
3*	399.434	25.0	2	1.486	アクリル
4	-111.618	175.122			

$R/f=r_{1x}/f=-0.514, r_4/f=-0.62114$, 第2レンズ群の焦点距離：f=179.7

この実施例に於いて、特殊トーリック面の主走査方向の形状即ち、特殊トーリック面を副走査方向から見た状態での形状は上記非球面の一般式で表される形状であり、この特殊トーリック面の光軸上に於ける副走査方向の曲率半径が上記$r_{1y}=29.480$である。

また結像レンズの入射側レンズ面（＊印を付けた面）も非球面である。

これらの非球面形状を規定する上記K,A,B,C,Dは以下の通りである。

特殊トーリック面の主走査方向の形状

$k=-6.32029\cdot10^{-1}$

$A=6.70608\cdot10^{-9}$,$B=5.99831\cdot10^{-12}$

結像レンズの入射側レンズ面

$k=-1.39881$

$A=-2.03709\cdot10^{-7}$,$B=5.14928\cdot10^{-11}$

$C=-1.26063\cdot10^{-14}$,$D=1.41459\cdot10^{-18}$

実施例2に関する収差図を第4図に示す。

（発明の効果）

以上、本発明によれば新規な光走査装置を提供

できる。この光走査装置では、第２レンズ群が像面湾曲補正面を有し、この像面湾曲補正面で副走査方向の像面湾曲を補正するので、走査面上のスポット形状の変動を有効に軽減ないし防止でき、従って400～800dpiという高分解能の光走査にも対応することができる。

また、偏向装置に最近接させて像面湾曲補正レンズ面を配するので、第２レンズ群を小型化でき、また光走査装置の大型化を招来することなく、光利用効率を著しく向上させることができる。

図面の簡単な説明

第１図は、本発明の特徴部分のレンズ構成を説明するための図、第２図は、上記特徴部分を説明するための図、第３図および第４図は、実施例に関連した収差図、第５図は、本発明の効果を説明するための図、第６図乃至第９図は、従来技術とその問題点を説明するための図である。

LI...線像、３...シリンドリカルレンズ、52...結像レンズ、51....像面湾曲補正レンズ

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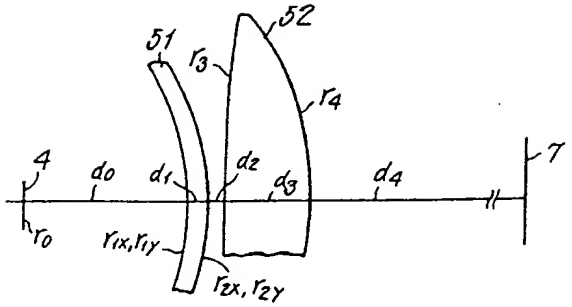
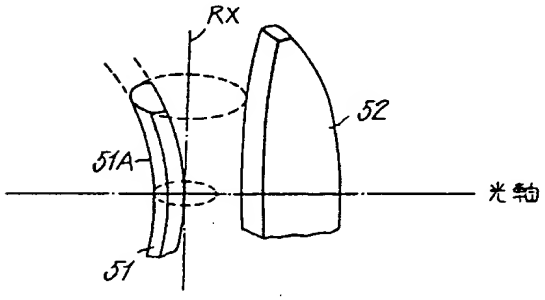
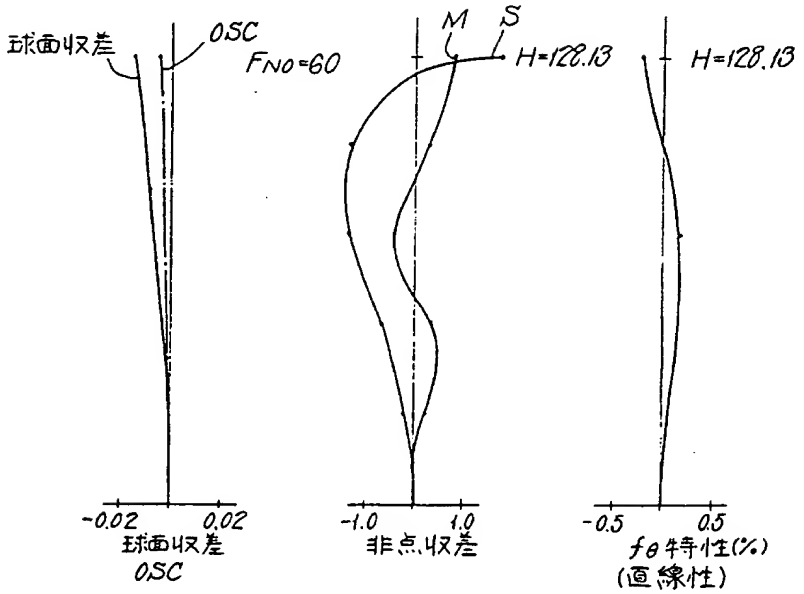
第１図



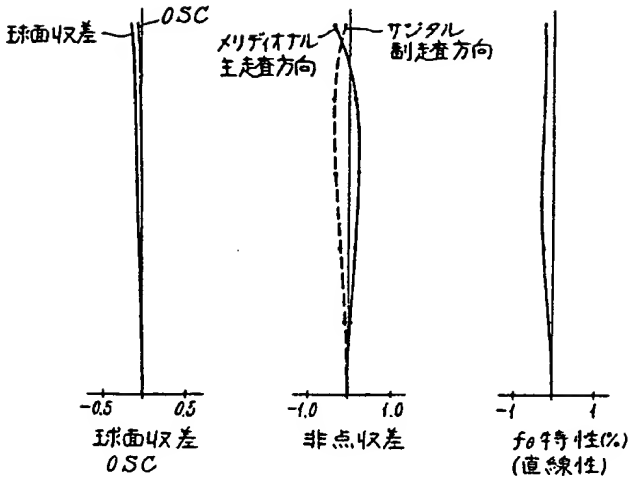
第２図



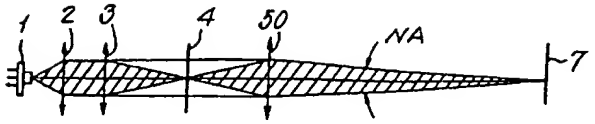
第３図



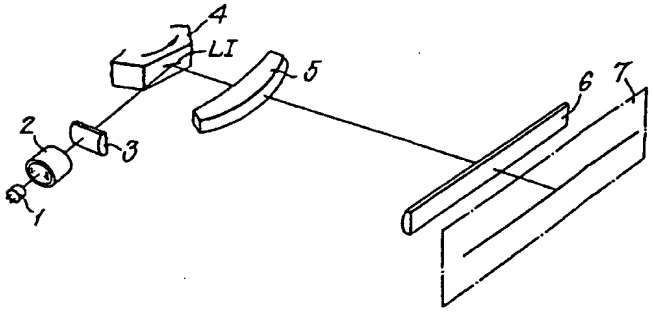
第4図



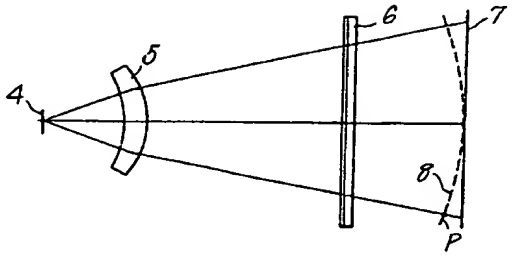
第5図



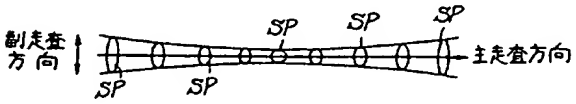
第6図



第7図



第8図



第9図